Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 63 (2014) 6945 – 6958

Energy Procedia

GHGT-12

The role of UNFCCC mechanisms in demonstration and deployment of CCS technologies

Paul Zakkour[a,*], John Scowcroft[b], Wolfgang Heidug[c]

[a]*Carbon Counts, 5 Dalby Road, London SW18 1AW, UK*
[b] *Global CCS Institute, Level 21, Bastion Tower, 5 Place du Champ de Mars, B - 1050 Brussels, Belgium*
[c] *Carbon Capture and Storage Unit, International Energy Agency. 9, rue de la Federation, 75739 Paris Cedex 15 France*

Abstract

The United Nations Framework Convention on Climate Change can provide an important source of financing and technological learning to support uptake of carbon dioxide (CO_2) capture and geological storage (CCS) in developing countries. In this context, a review of the current and future mechanisms for such support is outlined. Two important applications of CCS are considered further: CCS with CO_2 enhanced oil recovery (CO_2-EOR) and CCS on bioenergy emission sources (BECCS). Both technologies may be key to supporting near-term deployment of CCS in developing countries because of certain advantages they hold over other CCS applications.

Peer-review under responsibility of the Organizing Committee of GHGT-12

Keywords: Carbon capture and storage; UN Framework Convention on Climate Change; climate finance; developing countries; Technology mechnaism; New Market mechanism; Green Climte Fund; CCS with CO_2-Enhanced oil recovery (CO_2-EOR); Bioenergy with CCS (BECCS)

1. Introduction

The 1992 United Nations Framework Convention on Climate Change (UNFCCC or 'the Convention') is the primary international agreement aimed at preventing dangerous anthropogenic interference with the climate system[1].

* Corresponding author. Tel.: +44-20-8870-3330
E-mail address: paul.zakkour@carbon-counts.com

[1] Broadly agreed to be holding global average surface temperature increase to less than 2-degrees Celsius above pre-industrial levels. The Conference of the Parties to the UNFCCC are presently reviewing the adequacy of this target (under 'The 2013-2015 Review' process).

Peer-review under responsibility of the Organizing Committee of GHGT-12
doi:10.1016/j.egypro.2014.11.728

To achieve its objective, the 194 Parties to the Convention are obliged to, *inter alia*, establish polices and measures to reduce emissions of greenhouse gases to the atmosphere from anthropogenic sources, and to enhance the removal of greenhouses gases from the atmosphere by sinks and reservoirs.

Obligations under the Convention were enhanced by the 1997 Kyoto Protocol (KP), which entered into force in 2005. The KP set down quantified emission limitation and reduction obligations (QELROs) for the 37 developed country Parties listed in Annex B of the Protocol[2], obliging them collectively to an average aggregate greenhouse gas emission reduction of at least -5% compared to a 1990 base year over the first commitment period 2008-2012[3]. It also introduced the concept of 'flexible mechanisms' as a means for Parties to engage in emissions trading to meet their QELROs (or 'assigned amounts' when referring to the absolute emissions allowable over the first commitment period). The mechanisms are as follows:

- *International emissions trading* (IET) – where Annex B Parties can sell surplus assigned amount units (AAUs) left over from meeting their QELRO to other Annex B Parties which had emitted greater than their QELRO over the first commitment period;
- *Joint Implementation* (JI) – which allows Annex B Parties to invest into emission reduction projects in other Annex B Party countries, and generate emission reduction units (ERUs) which may be counted towards compliance;
- *Clean Development Mechanism* (CDM) – which allows Annex I Parties to invest into emission reduction projects in non-Annex B Party countries, and generate certified emission reductions (CERs) which may be counted towards compliance[4].

Together the UNFCCC and the KP have been major catalysts for incentivizing and financing technology transfer and investments into low carbon technology in developing countries. The policy architecture under the UNFCCC is presently in a state of transition, with a process in place to set down a new agreement and supporting mechanisms, expected to be in place after 2020. The current status and future potential for these processes and mechanisms to support the demonstration and deployment of CCS in developing countries is the focus of this paper.

Nomenclature

ADP	Ad hoc Durban Platform
CCS	Carbon dioxide capture and geological storage
CDM	Clean development mechanism of the Kyoto Protocol
CER	Certified emission reduction (unit under CDM)
CTCN	Climate Technology Centre and Network
FVA	Framework for various approaches
KP	Kyoto Protocol to the UNFCCC
NAMA	Nationally appropriate mitigation action
NMA	Non-market approaches
NMM	New market mechanism
PMR	Partnership for Market Readiness
QELRO	Quantified emission limitation and reduction obligations
UNFCCC	United Nations Framework Convention on Climate Change

[2] Parties listed in Annex B to the Kyoto Protocol, which covers a fairly similar list to that included in Annex I to the UNFCCC, but excludes Turkey and Belarus.

[3] The USA never ratified the Kyoto Protocol, whilst Canada withdrew in 2011.

[4] The CDM is sometimes referred to as an offsetting mechanism, as it allows Annex B Parties to meet their QELROs without taking domestic actions to reduce emissions but rather allows them to offset domestic emissions against reductions occurring elsewhere.

2. Finance and incentive mechanisms

Under the UNFCCC, developed country Parties are obliged to take the lead in tackling climate change, and to provide financial resources to developing country Parties to support implementation. A key part of the latter was the establishment of a Financial Mechanism of the Convention. The Financial Mechanism, via the *Global Environment Facility* (GEF), provides grants or concessional finance to promote technology transfer of low carbon technologies. So far it has supported over 600 climate change mitigation projects in developing countries, and mobilized over US$4 billion in direct and leveraged private co-finance (Table 1).

In addition to the Financial Mechanism, the KP's CDM augmented financial flows to emission reduction projects in developing countries. The CDM to date has mobilized up to US$30 billion in over 7,000 emission reduction projects over the last 10 years or so (Table 1). According to the *UNEP DTU Partnership*, the amount of capital investment mobilized under the CDM is in the order of US$400-450 billion since its inception [3].

Table 1. Financial flows, projects and emission reductions under the Financial Mechanism of the Convention and CDM

Funding source	Financial flow (US$ billions)	Projects (total number)	Emission reductions (tCO_2-equivalent)
Global Environment Facility (since 1991) [1]	4	639	-*
Clean development mechanism (2005-2015) [2]	10-30**	7000	2,000-3,000

Notes: Numbers have been rounded to ease readability. * Emission reductions under the GEF-5 replenishment are estimated to be around 510 $MtCO_2$-equivalent [1]. **Lower and upper limit calculated based on CER price of $5-10.

However, despite the various successes of the Financial Mechanism and CDM in mobilizing finance for emission reduction projects, and notwithstanding an agreement to extend the KP into a second commitment period (2013-2020)[5], there is widespread interest in reforming the architecture of climate finance mechanisms for the future, especially the CDM. This is for several reasons:

Firstly, the UNFCCC Secretariat estimates that more than $200-210 billion per annum needs to be spent on climate change mitigation measures in 2030 if emission reduction targets are to be met; more than half of which is required in developing countries [4]. Second, taking such levels of finance and their Convention obligations into account, under the 2009 *Copenhagen Accord* and 2010 *Cancun Agreements*, developed country Parties committed to "*a goal of mobilizing jointly USD 100 billion dollars a year by 2020 to address the needs of developing countries*" aimed primarily at mitigation [5, 6]. Some views consider that this amount should cover both adaptation and mitigation [7]. Third, there has been widespread criticism of the CDM, covering aspects such as environmental integrity, governance, high transaction costs, lack of additionality, poor distribution of projects, an inability to address development needs etc. [8]. More generally, it is unclear whether the CDM as a project-based offset mechanism is an appropriate instrument under which to mobilize such large amounts of capital; this is because its project-by-project approach cannot mobilize such large amounts quickly enough, whilst in theory there is a zero net reduction in emissions delivered through offset-based mechanisms.

In the context of CCS development and deployment, the existing mechanisms have also been something of a failure. Although the 'rulebook' for the CDM – known as 'modalities and procedures' – was established as early as 2001 [9], it took over six years from the time when the idea was first mooted in 2005 to approve specific CDM 'rules' for CCS project activities [10]. There were multiple reasons for this, which have been described elsewhere [11, 12].

[5] Albeit absent of the USA, Canada, Japan, Russia and New Zealand.

Problematically, the approval of the CCS CDM rules in late 2011 coincided with a downturn in interest in the CDM. This is largely a result of the lack of widespread participation in the second commitment period of the KP, and also the imposition of 'qualitative' restrictions on the use of CERs by European Union (EU) member states for meeting QELROs under the second commitment period. These restrictions – which apply in the absence of a binding international agreement on climate change – allow for only the use of CERs from new CDM projects registered from 2013 onwards occurring in Least Developed Countries or third countries with an agreement with the EU [13], of which for the latter there are none to date; CERs from CDM projects located elsewhere cannot be used by EU member states. Consequently, no new CCS CDM methodologies or projects have been proposed since the rules were agreed. The one CCS project proposed under the Financial Mechanism of the Convention – CO_2 capture and storage at a bioethanol refinery in Brazil – is reported to have been terminated without success [14].

The lack of tangible developments for CCS in developing countries under the UNFCCC to date notwithstanding, there is some cause for supporters of CCS to be optimistic about the future. As the UNFCCC process continues to set in train the Cancun Agreements [6] as well as seek to implement a supporting "*protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties*" under the Durban Platform [15], several new mechanisms are under consideration. This includes both market and non-market based approaches for finance, a 'framework for various approaches' (FVA), and a technology based mechanism and network, as discussed further below. There are also a number of activities taking place outside the auspices of the UNFCCC which are taking an active role in supporting CCS in developing countries, as described further below.

2.1. Future market-based approaches

A cornerstone of financing approaches under the Cancun Agreements is the establishment of a 'new market mechanism' (NMM), which has been agreed to be applicable under both the Convention and the Protocol. Discussions in these contexts are also closely entwined with the related 'framework for various approaches' (FVA), essentially a system to underpin the trading of different units. The NMM and FVA could provide the basis for financing emission mitigation projects and programmes in developing countries, probably from 2020. They are, however, something akin to the existing rules-based system applied under the Kyoto Protocol today. Under this, Annex B Parties are allowed to trade in assigned amount units (AAUs; which are equal to 1 tCO_2-equivalent for a Parties assigned under the first commitment period of the KP) and also allowed to use CERs and ERUs for compliance. The FVA in this current context relates to both the *IPCC Guidelines for Greenhouse Gas Inventories* which provide a common methodology for calculating national greenhouse gas inventories relative to a country's AAUs, the emission reduction *Approved Methodologies* under the CDM, and the system of *Registries* and the *International Transaction Log* (ITL) – an information-technology system for record-keeping on the location and transactions of AAUs, CERs and ERUs. However, there are some subtle differences within the NMM/FVA requirements.

Firstly, the NMM is to be applicable under the Convention, which means that it could potentially apply outside of a system of QELROs. As such, there is some uncertainty how a system of trading could be established absent of quantifiable emission limitations to drive demand and establish a compliance system. The present 'pledge and review' type approach to commitments under the UNFCCC emerging from the Copenhagen Accord and Cancun Agreements leaves significant latitude for countries to adopt different targets and responses towards emission reductions. Under such a framework, a plethora of regional cap-and-trade and domestic and bilateral offsetting mechanisms have evolved over recent years in regions such as California, China, New Zealand, Australia and Japan, and are under discussion in a number of developing countries (e.g. see the World Bank's *Partnership for Market Readiness*; PMR). But such schemes are not underpinned by any unifying scientifically-based emission reduction goal. Rather, they represent a fragmented system consisting of different targets, rules, and methodologies that are built on localized and politically-determined emission reduction or technology development goals. Consequently, the challenge is to bring such a fragmented set of schemes under the umbrella of a broader, liquid, global carbon market with interchangeable units whilst still maintaining a strong level of environmental integrity. One option

mooted has been the use of discount factors that are able to capture the variations between schemes and therefore account for differing environmental integrity; however, such an approach is unlikely to prove practical or politically workable (e.g. see [16]).

The result of this complexity means that progress on the matter within the context of UNFCCC negotiations has been fairly slow since the concept first emerged in 2010. Over the last year or so, however, activities have begun to take on more urgency – most likely driven by the strong connection between the mechanisms and the new legally-binding instrument foreseen under the Durban Platform [15] that is scheduled to be agreed at the Paris Climate Conference at the end of 2015. In this context, at the Doha Climate Conference in 2012 Parties agreed to establish a work programme to address, *inter alia*, the following elements of a NMM [17]:

- Standards that deliver real, permanent, additional, and verified mitigation outcomes, avoid double counting of effort and achieve a net decrease and/or avoidance of greenhouse gas emissions;
- Requirements for the accurate measurement, reporting and verification of emission reductions, emission removals and/or avoided emissions;
- Means to stimulate mitigation across broad segments of the economy, which are defined by the participating Parties and may be on a sectoral and/or project-specific basis;
- Criteria, including the application of conservative methods, for the establishment, approval and periodic adjustment of ambitious reference levels (crediting thresholds and/or trading caps) and for the periodic issuance of units based on mitigation below a crediting threshold or based on a trading cap;
- Criteria for the accurate and consistent recording and tracking of units;
- The facilitation of the effective participation of private and public entities;

Under this framework, a range of options for market-based mechanisms can currently be considered moving forward (Table 2). Presently it is not possible to provide a firm view on whether any or all of these mechanisms might materialize in the near-term, however; the examples outlined draw on various literature and decisions of the UNFCCC Conference of Parties

In respect of the NMM and the supporting FVA, the Parties to the UNFCCC emphasized at the Durban Climate Conference that such various approaches including use of markets must "*meet standards that deliver real, permanent, additional and verified mitigation outcomes, avoid double counting of effort, and achieve a net decrease and/or avoidance of greenhouse gas emissions*" [18]. Since then there has been broad agreement that the FVA could adopt one of three options in the future covering [19]:

1. A set of common rules. The FVA provides a set of uniform principles, standards and accounting rules for approaches that are adopted under the Convention and administered directly by Convention bodies;
2. A set of minimum criteria and review. The FVA provides a minimum set of common criteria for various approaches and some form of a review function to assess conformity with those common criteria;
3. A platform for the sharing of information, reporting and assessment. The FVA provides a platform for reporting and the sharing of information in a structured way, combined with some form of assessment to extract commonalities that can form the basis for common rules, standards, criteria and guidance.

These options leave a number of possibilities for future evolution of the carbon market, each with decreasing levels of centralized control and therefore review by the Conference of Parties and its supporting bodies under the UNFCCC. Consequently, some proponents could argue that the lower end under option 3 reduces the level of stringency and therefore environmental integrity potentially present under any future market mechanism. On the other hand, others might suggest it leaves greater flexibility in the market place to accommodate a wide range of evolving carbon units unified by a loose set of common principles governing their design, thereby increasing market liquidity and linkages across regions. There is some merit in both views.

Table 2. Options for mechanisms under the UNFCCC and future agreements thereunder*

Mechanism	Design features	Potential applicability	Relevance to CCS
Project-based approaches	Similar to current CDM, although perhaps including more Programme of Activities and greater use of Standardized Baselines	Probably limited to LDCs and to small-scale project applications	Unlikely to be a significant mechanism for CCS except in niche circumstances (e.g. small countries with limited power development). Maybe relevant in the fuel transformation sector (e.g. natural gas processing)
Nationally appropriate mitigation actions (NAMAs) with crediting	Gained traction within UNFCCC, although is yet to be full defined. For some simply a 'pledge' by a country under (e.g. Copenhagen Accord). For others, a policy or programmatic-based support mechanism [20]. Potential for some elements to be eligible for or subject to 'crediting'	Given the wide definition, likely to be widely applicable. Experiences to date suggest applicability may be limited to policies or programs that deliver systematic 'transformational change' such as under the BMU/DECC 'NAMA Facility' [21]. This allows the approach to shift away from baseline and crediting to more wholesale sectoral reforms within a country.	May be relevant in some contexts. Could apply to large CCS programmes in specific countries or regions covering *inter alia*: technical development, capacity-building, institutional support (e.g. establishment of research centres), and pilot-, demonstration- and/or commercial-scale project deployment with the possibility of crediting. Could cover capital expenditure and /or mechanisms to support ongoing operating costs.
Sectoral approaches	Based on either: *Sectoral crediting* – where a sector in a developing country takes on an agreed sectoral baseline, and reductions below this receive credits *Sectoral trading* – where sectors take on a global QELRO, and trade between themselves for compliance.	The concept has been around for several years. Seen as means to levelise asymmetries in greenhouse gas emission costs across industrial sectors globally. Considered by cement sector in 2009/10 [22, 23]. Also considered for iron & steel [24]	Levelising carbon emission costs to industry across jurisdictions could provide an important catalyst to CCS development in industrial sectors, both in developed and developing countries.

*Based on various sources. See e.g. [25] for a more detailed summary in the context of CCS

In the context of CCS, moving along the scale: option 1 would involve something similar to CDM type rules in operation today, and would likely draw heavily upon the existing modalities and procedures for CCS projects under the CDM [10]; option 3 would see a plethora of different methodological approaches that may be applied to CCS, aligned to some common principles. Problematically, in the case of the latter there are already a range of project-based carbon 'credit' rules in existence for CCS today, covering both the CDM rules [10] and approaches developed in e.g. the US and Canada [26, 27] – as it currently stands, there are significant differences between these methodologies, in particular with respect to matters such as additionality, site selection, monitoring and emissions leakage[6]. As such, as countries rapidly forge ahead in establishing their own emissions trading schemes outside of the UNFCCC process – for instance under the World Bank's PMR – there is a risk of significant divergence in approaches, ultimately leading to the type of fragmentation in the carbon market described above, with lower assurances over environmental integrity. It will also leave developers facing differential standards for project

[6] Emissions leakage in this context refers to as the potential for net changes in emissions to occur outside the boundaries and operational control of a particular policy and/or activity, but arising as a consequence of the policy and/or activity. For example, in CO_2-EOR projects, the emission associated with the combustion of incremental oil produced.

development across different jurisdictions, and pose risks for project failures due to poor levels of regulatory control. Such outcomes will ultimately result in a less liquid market and potentially reduce confidence in CCS technologies. So, on the one hand, whilst a fragmented approach may be more attractive to CCS developers because of lower regulatory hurdles based on jurisdiction-specific approaches, on the other, the fragmented nature may reduce demand and therefore prices for carbon credits generated from e.g. CCS projects under a particular scheme. Resolution of these items form a critical issue for negotiations on the NMM and FVA moving forward, and will have important ramifications for the way that CCS may be incentivised and implemented using carbon finance in the future.

2.2. Future non-market based approaches

A further element of the 2010 Cancun Agreements [6] was the agreement to establish non-market based approaches (NMA) under the UNFCCC. The scope of the NMA was however, poorly defined, and sat alongside existing non-market based elements under the UNFCCC including the *Technology Mechanism* (see below) and *Green Climate Fund* (GCF) already pledged in the Copenhagen Accords [5], as well as other NMAs already existing in the UNFCCC system (e.g. the Adaptation Fund, initiatives for REDD+[7], Financial Mechanism of the Convention etc.). As such, progress on the NMA under the UNFCCC has been slower than that of the NMM. Presently there is a need to improve clarity about the NMA with respect to activities or sectors to be targeted, types of funding, and disbursement methods etc.

However, the principal element of the new UNFCCC NMA is the GCF. This is expected to be the primary pathway for the "*mobilizing jointly* [of] *USD 100 billion dollars a year by 2020 to address the needs of developing countries"* pledged under the Copenhagen Accord. So far the GCF has established a Secretariat in Songdo, South Korea, and put in place a twenty-four man board selected by Parties to the UNFCCC to govern its operation. The principle mechanisms for supporting low carbon technologies are envisioned to be [28]:

- Grants – no repayment required;
- Concessional loans (deeply concessional) at 0 per cent interest over 15 to 40 years; and
- Concessional loans (moderately concessional) – at interest rates to be determined but likely to be equivalent to European Central Bank rate or US Treasury bond rate over 8 - 15 years.

To guide its investment strategy, the GCF Board has established some guiding principles including [28]:

- Grants should be tailored to incremental cost or the risk premium required to make the investment viable, or to cover specific activities such as technical assistance;
- Seeking the right level of concessionality, so as not to displace investments that would otherwise have occurred, including for private sector investment;
- Structure terms on a case-by-case basis to address specific barriers;
- Avoid crowding out commercial financing;
- Leveraging of other financing, including public and private financing, seeking to maximise leverage in the case of private financing;

These sort of criteria suggest that CCS – with its high upfront investment cost, the incremental nature of the investment (for new facilities) and its lack of commercial incentives beyond carbon emissions pricing – could fit to

[7] Reducing emissions from deforestation and forest degradation, and the role of conservation and sustainable management of forests and enhancement of forest carbon stocks in developing countries.

many of the lending criteria of the GCF. Moreover, its sectoral focus includes "low carbon power generation" and its performance metrics suggest that CCS looks well suited to the fund. Performance indicators include [28]:

- Tonnes of greenhouse emissions produced, with the intention of reducing emissions relative to a 'without project' baseline,
- Cost per tonne of CO_2-equivalence reduced, and
- Volume of public and leveraged private funding.

A range of other criteria are also under development, including regional and economic priorities and the financial viability of the activity. The GCF has a long way to go to be fully operational and reach the levels of mobilizing 100's of millions of US dollars per year for low carbon technology. For example, as of March 2014, the GCF had received pledges and contributions from fifteen countries totaling only US$ 54.9 million [29]. As such, it is extremely uncertain as to whether the GCF will ever reach the ambitious levels envisioned by many, meaning that its capacity to support future CCS deployment may be limited by a lack of capitalization.

2.3. Future pathways for climate finance

In considering how climate finance may evolve over coming years, the diagram below (Fig. 1) attempts to highlight the potential outcomes based on two key criteria that will affect the shape and scale of future mechanisms, namely:

1. *The level of ambition* – this component captures the political uncertainty surrounding emission reduction targets that might be adopted by countries in 2020 and the associated amounts of climate finance flowing from developed countries to developing countries at that time. It will, in part, be influenced by 'The 2013-2015 Review' which will set the scientific basis for emission reduction efforts (see footnote 1). The level of public and private money made available clearly has effects on the abilities of developing country governments to mobilise investment into low-carbon technologies. The current status is a patchwork of some developed countries having adopted QELROs under the Kyoto Protocol with others, including most developing countries, having adopted no targets and having limited climate change policies and measures. One end of the range represents a weak level of ambition with no countries adopting meaningful targets; the other end represents an ambitious policy framework in which all countries adopt QELROs negotiated in support of a globally agreed, legally-binding, emission reduction agreement e.g. under a global protocol or instrument as a successor to the KP; and,
2. *The use of market and/or non-market based approaches* – this component seeks to capture the range of potential outcomes regarding the use of market and non-market mechanisms to channel finance to low-carbon technology projects in developing countries. The current position is one in which some developed country Parties to the Kyoto Protocol make use of international offsets within their domestic emissions trading schemes, principally through the project-based CDM. One end of the range represents a growth in regional emissions trading schemes with an increased use of international offsets through e.g. an expanded and reformed CDM and/or new market-based mechanisms such as credited NAMAs, sectoral crediting or trading etc.; the other end represents a prevalence of non-market based schemes such as the use of bilateral, multilateral and UNFCCC funds to channel climate finance into developing countries. Under this scenario, developed country emissions trading schemes may increase the linkages to enhance cost-effectiveness rather than through project- or programmatic-based offsets.

The schematic is illustrative only. However, it does allow for a useful discussion of four broad 'pathways' – or scenarios – concerning how the international climate policy architecture could develop over the coming 5-10 years, and beyond. A more detailed assessment of these pathways is available elsewhere (e.g. [25, 30]).

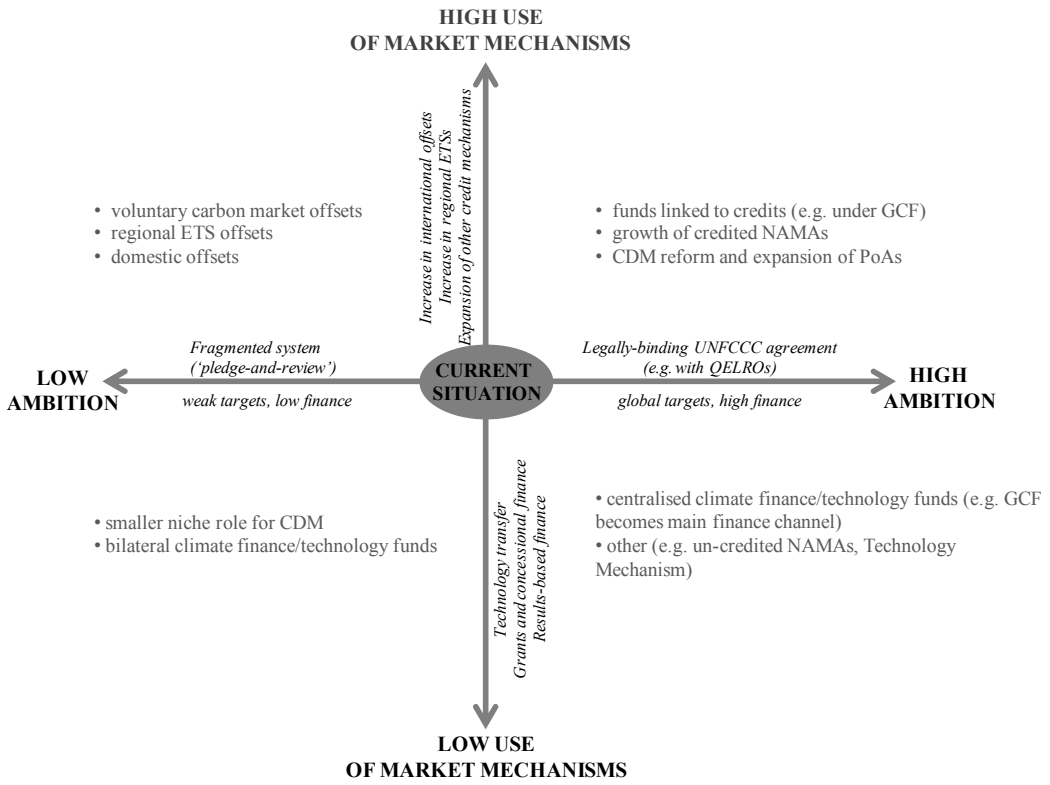

Fig. 1. Scenarios for future climate finance (adapted from [25])

3. Mechanisms for technology support

The UNFCCC has long recognised the value of technology development and transfer in the enhancement of mitigation aspirations of countries, as well as in support of their sustainable economic development goals. In 2010, a *Technology Mechanism* was established under the Cancun Agreements [6]. The mechanism is supported by two separate institutions: the *Technology Executive Committee* (TEC) – charged with advising Parties on technology policy matters; and the *Climate Technology Centre and Network* (CTCN) – which is tasked with implementing support actions as requested by countries in regards to their technology needs.

The Technology Mechanism simultaneously supports technology policy development and practical actions. The TEC continues the work of the previously established UNFCCC *Expert Group on Technology Transfer* in providing high-level advice to governments on how to better prioritize resources in support of their mitigation and adaptation needs. It is organizationally independent to the CTCN, but collaborates very closely in its order of business.

The CTCN is an innovative 'demand-driven and participatory' approach adopted by the UNFCCC to give effect to real and localised climate technology friendly outcomes in countries [31]. It exercises operational independence through its consortia host, led by the UN Environment Programme (UNEP), while still being accountable to the COP for its performance through its Advisory Board. The private sector sits by invitation on its Advisory Board, which not only enhances the quality of its decision making but has established a precedent for the private sector to also participate in the governance decisions of the US$100 billion per year in 2020 Green Climate Fund.

The CTCN aims to reduce the risks and costs of technology development and transfer by assisting developing countries make more informed decisions about technologies of interest, especially in regards to their acceleration, diversification and scale-up. It serves three core functions:

1. Manage and respond to requests;
2. Foster collaboration and access to information and knowledge; and
3. Strengthen networks (through the CTN), partnerships and capacity building for technology transfer.

The CTCN's services cover requests by developing countries that demonstrate a potential to enhance just about any stage of any 'environmentally sound' technology's innovation process, ranging from addressing policy, financial and technical bottlenecks to supporting R&D, demonstration or deployment activities. The nature of requests might include for example:

- Technical support and advice (including for projects);
- Strategic policy and implementation advice;
- Project level advice and support;
- Training and capacity building support

There is scope for such services to be financially supported by the CTCN and/or delivered in partnership with its CTN. The Network currently has some 14 members, including the *Global CCS Institute* who will be dealing with requests from developing countries in relation to CCS.

It seems unlikely that the CTCN will be able to directly finance projects – funding for the Centre is still being sought beyond the original grants – but will mainly concentrate on capacity building. In the medium- to long-term, both the TEC and the CTCN will look to bodies within the UNFCCC's Financial Mechanism – notably the GCF (see above) and GEF, and other market- and non-market based approaches as outlined above, to provide financing support to projects on the ground. Discussions are on-going between the *Standing Committee on Finance* – a body that is overseeing the longer-term financing commitments under the Convention – and the TEC on the appropriate modalities through which they can collaborate on bringing funding to non-Annex I countries.

4. Supporting special technology applications

4.1. Enhanced oil recovery and CCS (CO_2-EOR)

A particular interest of many developing countries is in putting captured CO_2 to use in order to realize some other beneficial outcomes other than just mobilizing large amounts of capital to simply put CO_2 in the ground for climate change mitigation purposes. This is not surprising since – as emphasized in the UNFCCC text – their obligations to reduce emissions are less onerous than those faced by developed countries. These sentiments are reflected in recent activities within and outside of the UNFCCC. To illustrate: under the *Clean Energy Ministerial* initiative, efforts to engage with developing country members on CCS has led to a focus on CCUS, the 'U' being for utlisation [31], whilst more recently the scope of a planned *Technical Expert Meeting* under the ADP scheduled for October 2014 is seeking to include discussions not only on CCS, but also on CO_2 use [33]. One key technology in this context is the injection of CO_2 into oil mature reservoirs to improve the recovery of crude oil, a process known as CO_2-enhanced oil recovery (EOR). This is today by far the largest scale technology option available for utilising CO_2.

Problematically, discussions involving the use of climate finance to support fossil fuel production tends to create tensions in UNFCCC fora, primarily due to concerns over 'carbon lock-in' and emissions leakage. As such, CO_2-EOR has not been widely discussed in UNFCCC negotiations, and there remains latitude for impeding its eligibility for climate finance within the system. An indication of the range of views on the technology are only likely to fully emerge if a CO_2-EOR project were to be proposed under the CDM. Presently whilst it is not specifically excluded under CDM modalities and procedures [10], it is also not explicitly included. As such it is likely that such a

development would lead to a lengthy debate about the merits and risks of the technology, serving to provide an important measure of the future potential for CO_2-EOR under future climate finance mechanisms and approaches.

But in terms of supporting near-term deployment of CCS, CO_2-EOR seems like a critical catalyst. The revenues that it can generate from oil sales make it especially important for early-opportunity application to get the technology off the ground and achieve early learning and cost reductions through better understanding of systems integration. This can then be used to support CCS deployment as part of an economically optimal longer-term mitigation strategy as envisaged under most recent models of greenhouse gas mitigation [34, 35]. This view is especially true in places such as the Middle East, but also in potentially in South East Asia, West Africa, Brazil and other parts of the world with large hydrocarbon developments and significant sources of high-purity CO_2 [36]. While CO_2-EOR as practiced today is a technically mature option to enhance oil production, its use as a climate mitigation technology requires further development. For example, there is the possibility to reconfigure traditional approaches to CO_2-EOR to enhance the mass of CO_2 stored, and also to potentially convert CO_2-EOR projects to storage projects once recovery of the oil in the reservoir is no longer economically viable [37]. For these reasons, consideration of the potential role of CO_2-EOR in supporting emission reductions in developing countries, and its eligibility under climate finance warrants further consideration [38].

4.2. Bioenergy and CCS (BECCS)

Another important technology that merits further consideration for near-term CCS financing is bioenergy applications with CCS (or 'BECCS'). Since biomass combustion or processing could give rise to zero-rated emissions – a result of the assumed uptake of the CO_2 by further growth of new biomass – the capture and storage of these emissions can give rise to so-called 'negative emissions'. Negative emission applications, relative to the application of CCS to fossil fuel emissions sources, may be important for a number of reasons including:

- The capacity to accelerate reductions in atmospheric concentrations of CO_2 compared to just reducing emissions; The capacity to remove or compensate for historical emissions by removing their legacy from the atmosphere – these aspects are important if action to mitigate greenhouse gas emissions is delayed in the first part of this century; and,
- The ability to reduce the overall costs of climate change mitigation by offsetting more difficult to abate – or "recalcitrant" – emission sources (e.g. emissions from aviation) [39, 40, 41, 42]

The application of BECCS technologies could be particularly interesting for countries such as Brazil or in South East Asia where large bioenergy resources exist.

Further, the potential benefits of 'negative emissions' could suggest that the allocation of additional incentives to BECCS technologies could be warranted ahead of other fossil-fuel based CCS applications, especially in regions where geological storage capacity may be limited. However, there are several problems associated with promoting widespread uptake of BECCS and careful consideration is required for the design of incentive mechanism for BECCS. Aspects to consider include:

- Broader land use, land use change and forestry (LULUCF) impacts from widespread bioenergy production is needed to ensure sources are sustainable and not leading to widespread loss of soil and biological carbon stocks, forest degradation, monoculture and ecosystem loss. Precedents exist in the current CDM, which could be drawn on to manage this risk;
- Design of the baseline to ensure that the negative emission quotient is adequately recorded in a greenhouse gas accounting method employed to assess the reductions achieved by BECCS projects;
- Consideration of the need to potentially create additional incentives for BECCS ahead of just deploying biomass energy generation (which also attracts zero carbon price risks under most emission control schemes today); and,
- Ensuring that incentives for BECCS do not diminish the importance of CCS on fossil-fuel emission sources.

A review of these challenges have been outlined elsewhere (e.g. [39]).

5. Other ongoing activities outside UNFCCC

Notwithstanding the apparent current lack of interest in CDM and slow pace of future developments under the UNFCCC to support CCS in developing countries, there is a plethora of ongoing efforts taking place outside the direct auspices the Convention which are serving to build momentum for CCS understanding in many developing countries. Such initiatives are donor-led – primarily through Norway, Australia and UK – and also other activities taking place under e.g. the Clean Energy Ministerial and *the Asia Pacific Economic Cooperation* (APEC) forum.

In the case of the former over US$100 million has been mobilized through World Bank and Asian Development Bank trust funds to support efforts to establish knowledge and understanding of CCS potential in a diverse range of countries including Botswana, China, Egypt, Indonesia, Jordan, Kosovo, Mexico, Morocco and South Africa. A leading example amongst these is the financing being provided for development of the *Pilot CO_2 Storage Project* being run by the *South African Centre for CCS*. Another major development is the support provided by the ADB to the GreenGen CCS project in China. APEC is also providing capacity building support to countries such as Mexico and Indonesia.

Consequently, whilst CCS continues to navigate a difficult pathway through the UNFCCC process, the lack of progress should not be seen to be the driving down interest in CCS in developing countries – on the contrary, concern over this absence relative to the perceived importance of CCS as a climate mitigation technology in many non-OECD regions is forcing donors to take specific actions to build momentum for CCS at the current time. Consequently, there are reasons to be positive that as and when activities such as the NMM, NMA and GCF become fully operationalised, there will be an established base of recipients ready to launch into CCS project development suing these new sources of finance.

6. Conclusions

The UNFCCC and related mechanisms are likely to be an important catalyst for supporting project investments, capacity building and technology transfer for CCS in developing countries over the medium-term (by 2020). Primarily the NMM, NMA and GCF will be the main channels for project finance and other incentives, whilst the technology mechanism and CTCN will form the main channel for institutional support around capacity-building and technical learning. The GCF already appears to be making progress in its design features, and many of the elements agreed so far appear suitable for supporting CCS.

The precise nature of both market- and non-market based mechanisms and approaches need much further refinement to become operational, although in the lead up to the Paris Climate Conference (in late 2015) it is likely that significant progress will be made to elaborate further elements of their design.

Any new mechanisms under the UNFCCC are likely to build from the rules already in place for CCS projects under the CDM. As such, whilst there is presently diminished interest in CDM today, the CCS modalities and procedures still have currency in terms of designing new mechanisms to support the technology. These will be equally applicable to both NMM and NMA mechanisms.

If a fragmented global carbon market evolves under a weakly structured FVA, it is likely that the standards applicable to CCS implementation across the world will be variable. This would create issues for project developers and affect the fungibility and liquidity of any carbon ‘credits’ generated by a CCS project. This in turn could potentially reduce the price and therefore finance available to support CCS through the carbon market.

Two important technologies that could catalyse uptake of CCS in developing countries warrant further consideration as to their status and the type of incentives to be applied under UNFCCC mechanisms: CO_2-EOR and

BECCS. Both technologies can offer advantages relative to 'pure' geological storage using CCS on fossil-fuel emission sources, albeit with some additional aspects to consider in relation to emissions leakage and sustainability impacts.

Whilst progress in the UNFCCC system has proved slow for CCS, several donor-led activities occurring outside of the direct auspices of the UNFCCC are working to support CCS knowledge development and project deployment in developing countries. The most notable of these are being led by the World Bank and Asian Development Bank, and providing significant grants to activities in both South Africa and China respectively, as well as other pockets of activities in other jurisdictions.

It is conceivable to consider that the donor-led initiatives occurring outside of the UNFCCC today are creating an important base from which to fast-track CCS deployment in developing countries, if, as and when the full suite of climate finance mechanisms have properly emerged under the ongoing processes inside the UNFCCC.

References

[1] GEF, *Report of the Global Environment Facility to the Nineteenth Session of the Conference of Parties to the United Nations Framework Convention on Climate Change*. July 1, 2013. UNFCCC Document FCCC/CP/2013/3

[2] Based on data from the UNFCCC CDM website: http://cdm.unfccc.int/Statistics/Public/CDMinsights/index.html accessed August 2014.

[3] UNEP DTU CDM/JI Pipeline Analysis and Database, August 1st 2014

[4] UNFCCC. *Investment and Financial Flows to Address Climate Change: an update*. UNFCCC Technical Paper FCCC/TP/2008/7, 26 November 2008

[5] UNFCCC. *The Copenhagen Accord*. As appended to Decision 2/CP.15. para. 8. December 2009.

[6] UNFCCC. Decision 1/CP.16. *The Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention*. December 2010.

[7] UN. *Report of the Secretary-General's Hig h-Level Advisory Group on Climate Change Financing*. 5 November 2010.

[8] See for example, Michaelowa, A., 2012. *Strengths and weaknesses of the CDM in comparison with new and emerging market mechanisms*. Paper No. 2 for the CDM Policy Dialogue, June 2012.

[9] UNFCCC. *The Marrakesh Accords - Modalities and procedures for a clean development mechanism, as defined in Article 12 of the Kyoto Protocol*. Decision 17/CP.7. November, 2001. Formalised under the CMP by way of Decision 3/CMP.1, 2005.

[10] UNFCCC. Decision 10/CMP.7 *Modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities*. December, 2011.

[11] Zakkour, PD. *Accessing carbon finance for CCS projects in emerging and developing economies*. Chapter 16, pp. 233-251 in: Havercroft, I, Macrory, R. And Stewart, R. (eds) *Carbon Capture and Storage: Emerging Legal and Regulatory Issues*. Wildy & Sons, Oxford, UK. 2011.

[12] Dixon, T, Leamon, G, Zakkour, PD and Warren, L. CCS projects as Kyoto Protocol CDM activities. *Energia Procedia 31*. 2013. p. 7596-7604. GHGT11.

[13] As set out in Article 11a of *Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC*, as amended by Directive *2009/29/EC of the European Parliament and of the Council of 23 April 2009, amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community*.

[14] GCCSI, ADB, WRI. *Making the case for funding carbon capture and storage in developing countries*. March 2013.

[15] UNFCCC. Decision 1/CP17. *Establishment of an Ad Hoc Working Group on the Durban Platform for Enhanced Action*. December 2011.

[16] Kollmus, A, Lazarus, M and Smith, G. *Discounting Offsets: Issues and Options*. Stockholm Environment Institute Working Paper WP-US-1005. 2010.

[17] UNFCCC. Decision 1/CP.18. *Agreed outcome pursuant to the Bali Action Plan*. December, 2012.

[18] UNFCCC. Decision 2/CP.17. *Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention*. paragraph 79. Durban, 2011.

[19] UNFCCC. Document FCCC/TP/2013/5. *Technical synthesis on the framework for various approaches*. October 2013.

[20] See for example, UNFCCC. Document FCCC/SBI/2013/INF.12/Rev.2. *Compilation of information on nationally appropriate mitigation actions to be implemented by developing country Parties*. May, 2013. This document sets out in the context of 'NAMAs', all pledges received from developing country Parties in response to the Copenhagen Accord and Cancun Agreements. It includes proposals ranging from economy-wide emission reduction targets from some countries (e.g. South Africa, India, Kyrgyzstan), list of sectors to be targeted for mitigation (e.g. Brazil, Burkina Faso, Gambia, Indonesia), lists of polices and measures being implemented (e.g. Argentina), and lists of projects to be implemented (e.g. Ethiopia, Jordan).

[21] BMU/DECC. *NAMA Facility: General Information Document*. April, 2014. Germany Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety and UK Department of Energy and Climate Change NAMA Facility guidelines.

[22] WBCSD-CSI. A Sectoral Approach – Greenhouse Gas Mitigation in the Cement Industry. World Business Council for Sustainable Development, Cement Sustainability Intiaitve. 2009

[23] Cook, G. *Investment, Carbon Pricing and Leakage - a cement sector perspective*. A report for Climate Strategies. September 2011.
[24] Wooders, P, Cook, G, Zakkour, P, Harfoot, M and Stieber, S. The Role of Sectoral Approaches and Agreements: Focus on the Steel Sector in China and India. A report for Climate Strategies, December 2009.
[25] Zakkour, PD, Cook, G, Carter, A, Streck, C and Chagas, T. *Assessment of climate finance sources to accelerate carbon capture and storage deployment in developing countries*. A report by Carbon Counts and Climate Focus for the World Bank. 16th June 2011. Washington D.C.
[26] For example, under the Alberta Specific Gas Emitters Regulation, offsests units may be used for compliance from CCS projects based on: *Quantification Protocol for Enhanced Oil Recovery*, Alberta Environment, October 2007; and, the Province is also considering a methodology for *Capture of CO_2 and Permanent Storage in Deep Saline Aquifers,* 2011.
[27] American Carbon Registry. Greenhouse Gas Emissions Reduction Measurement and Monitoring Methodology for Carbon Capture and Storage Projects in Oil and Gas Reservoir.
[28] Bonner, M. *Green Climate Fund progress – on the "Road to Paris" via New York*. Global CCS Institute, Insights. 22 May 2014.
[29] Green Climate Fund Trust Fund. *Financial Report prepared by the Interim Trustee* (The World Bank). March 31, 2014.
[30] ECA and Carbon Counts. *Low Carbon Study on Carbon lock-in at the country level in ICF priority countries*. 2014. Draft report to UK Dept. for International Development (DfID) and Dept. for Energy and Climate Change, August 2014, unpublished (in progress).
[31] Climate Technology Centre and Network. *A Stakeholders Perspective on opportunities and Challenges for Climate Technology Facilitation in Developing Countries: informing the Operation of the Climate Technology Centre & Network*. 2014 CTCN Regional Expert Dialogue paper /UNEP Regional Expert Dialogues report (AB/2014/3/8)
[32] Clean Energy Ministerial, Carbon Capture, Utilization and Storage (CCUS) Action Group – information available at: http://www.cleanenergyministerial.org/Our-Work/Initiatives/Carbon-Capture
[33] Information available at: https://unfccc.int/bodies/awg/items/8421.php
[34] For example, the International Energy Agency envisages nearly 8,000 $MtCO_2$/year being injected in 205, of which over 60% takes place in developing countries. See: IEA. *Technology Roadmap Carbon Capture and Storage*. 2013. IEA/OECD, Paris.
[35] Intergovernmental Panel on Climate Change. See: Working Group III contribution to the IPCC 5th Assessment Report - *Climate Change 2014: Mitigation of Climate Change*. IPCC, Switzerland.
[36] Zakkour, PD and Cook, G. *CCS Roadmap for Industry: High Purity CO_2 Sources*. September 2010, Report to the United Nations Industrial Development Organisation (UNIDO)
[37] For example, see: International Energy Agency. *Joint IEA-OPEC workshop on CO_2-enhanced oil recovery with CCS.* February 2012. IEA/OECD, Paris.
[38] International Energy Agency. *Harnessing the potential of enhanced oil recovery for CO_2 storage*. 2014 (forthcoming)
[39] Zakkour, PD. Cook, G. and French-Brooks, J. *Biomass and CCS – guidance for accounting for negative emissions*. 2014. Report for the IEA Greenhouse Gas R7D Programme, Cheltenham, UK.
[40] McLaren, D. *Negatonnes – an initial assessment of the potential for negative emission techniques to contribute safely and fairly to meeting carbon budgets in the 21st century*. Report for Friends of the Earth, UK. September 2011.
[41] Socolow, R. Negative Emissions: Comprehending Scale. *Presentation to the International Workshop on Modelling and Policy of CO_2 removal from the Atmosphere*. 30 May, 2011. Venice, Italy.
[42] McGlashin, N, Workman, NH, Caldecott, B, Shah, N. *Negative Emission Technologies*. Grantham Institute for Climate Change, Imperial College, London. Briefing Paper No. 8. October 2012, London.